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MÖSSBAUER STUDIES OF Fe^{2+} AND Fe^{3+} MIXED STATE IN ILMENITE-HEMATITE SOLID SOLUTION

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Recently, the doping of corundum-related α-Fe_2O_3 has very attracted interest because of room-temperature magnetic semiconductor for spintronics materials.[1,2] Both ilmenite, $FeTiO_3$ and hematite, α-Fe_2O_3, have the rhombohedral structure. α-Fe_2O_3 can be visualized as consisting of layers of Fe ions in the (111) planes with oxygen layers between them. The structure of $FeTiO_3$ can be derived from that of α-Fe_2O_3 by replacing every other layer of Fe ions by a layer of Ti ions. The both compounds, Fe spins are parallel within a given (111) plane and antiparallel between adjacent planes showing antiferromagnetism. The $0.9FeTiO_3$-$0.1Fe_2O_3$ solid solution were prepared by solid state reaction with $FeTiO_3$ and α-Fe_2O_3 powders, and studied by x-ray diffraction, Mössbauer spectroscopy, and vibrating sample magnetometer (VSM). The examination of these solid solution by Mössbauer effect in ^{57}Fe gives new information concering the magnetic as well as chemical environment. The crystalline structure was found to be single phase rhombohedral structure with lattice constants a = 5.089 Å and c = 14.051 Å. Mössbauer spectra of $0.9FeTiO_3$-$0.1Fe_2O_3$ solid solution were taken at various temperature ranging from 4.5 to 295 K. The anomalous absorption curves are observed. For $0.9FeTiO_3$-$0.1Fe_2O_3$ solid solution sample, the Mössbauer spectra at 4.5 K was fitted to three six-line hyperfine pattern with magnetic hyperfine fields H_{hf} = 498, 379, and 202 kOe, respectively. Above 50 K, the spectrum show asymmetry two-line pattern. The fitted curves at room temperature are obtained by superimposing two doublet, the one corresponding to Fe^{2+} and the other to Fe^{3+}. The isomer shift δ and quadrupole splitting ΔE_Q of $0.9FeTiO_3$-$0.1Fe_2O_3$ solid solution is 0.92, 0.14 mm/s and - 0.69, - 0.29 mm/s, respectively as expected for Fe^{2+} and Fe^{3+}. Corresponding relative absorption subspectral areas are 89.2 % for Fe^{2+} and 10.8 % for Fe^{3+}. The temperature dependence of the magnetization taken in zero-field-cooling (ZFC) and field-cooling (FC) condition of the $0.9FeTiO_3$-$0.1Fe_2O_3$ sample exhibits no great irreversibility between ZFC and FC magnetization. Magnetization measurements indicate ferromagnetic behavior with 92 Oe coercivity value at 50 K but at 300 K show no hysteresis loop. The magnetic Néel temperature (T_N) was determined to be 98 K by zero field cooled magnetization curves under the 100 Oe applied field. From these results, it is considered that some kind of ferromagnetic small clusters created by incomplete chemical order in $0.9FeTiO_3$-$0.1Fe_2O_3$ solid solution exist.

[1] T. Droubay, K. M. Rosso, S. M. Heald, D. E. McCready, C. M. Wang, and S. A. Chambers, Phys. Rev. B 75, (2007) 104412.
[2] J. Velev, A. Bandyopadhyay, and W. H. Butler, Phys. Rev. B 71, (2005) 205208.